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ABSTRACT

The purpose of this research was to explore the level of perceptual processing being used by normal and educable mentally retarded beginning readers. The investigation tested the hypothesis that beginning readers show a positive relationship between word length and word recognition latency, implying serial processing. Data on accuracy and latency in reading words of different lengths was collected as well as comprehension data. Both mentally retarded and normal children took longer to read longer words than shorter words, implying letter-by-letter processing. Differences in accuracy and latency of word recognition were able to explain differences in comprehension. A possible implication is that aiding children in becoming fast, accurate decoders may facilitate comprehension. (Author/TS)

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An Investigation of Serial Versus Parallel Processing in Normal and EMR Beginning Readers

Session - Thurs. 10:45-11:45 a.m.
Research Report
Disneyland Hotel, South Lounge

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AN INVESTIGATION OF SERIAL VERSUS PARALLEL PROCESSING IN NORMAL AND EMR BEGINNING READERS

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Abstract

The investigation tests the hypothesis that beginning readers (EMR and normal) show a positive relationship between word length and word recognition latency, implying serial processing. Accuracy and latency to read words of different lengths was collected as well as comprehension data. Both mentally retarded and normal children took longer to read longer words than shorter words, implying letter-by-letter processing. Differences in accuracy and latency of word recognition were able to explain differences in comprehension. A possible implication is that aiding children in becoming fast, accurate decoders may facilitate comprehension.

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PURPOSE:

The purpose of this research was to explore the level of perceptual processing being used by normal (N) and educable mentally retarded (EMR) beginning readers. Disagreement exists concerning the ways beginning and skilled readers differ in their processing of written materials. Opinions in this long-standing debate range from those who view reading as a process of serially processing words letter-by-letter to those who believe that larger units than the individual letters, such as syllables, morphemes or words are recognized as chunks or wholes by processing several of the letters simultaneously in parallel.

Aside from the theoretical interest, this controversy has important pedagogical implications since it may influence the teaching strategies used with non-readers and poor readers in the effort to help them attain literacy. Views on questions such as "Is processing during reading serial or parallel?" can lead to pedagogical decisions such as whether reading should be taught as a series of subskills or as a wholistic process.

LITERATURE REVIEW:

Evidence for Parallel Processing of Letters in a Word

The dispute over whether words are recognized mainly by serial processing or parallel processing has continued for almost a century. The experiments of Cattell (1885) have often been used as evidence of parallel

processing and support for the whole word method of teaching reading. Cattell had fluent readers read passages from Gulliver's Travels, read lists of nouns and spell out letters. When subjects required approximately the same amount of time to read either the words or the letters, Cattell concluded that subjects were recognizing words as wholes. In a separate experiment he showed that short words could be identified as quickly as single letters. It should be pointed out that only skilled readers were used in Cattell's experiments and also, time to pronounce words was confounded with the time to recognize the word.

Erdmann & Dodge (1898, quoted Huey, 1908) tested recognition times for words of different lengths (4, 8, 12, 16 letters) and found that the longer words needed comparatively little additional time--the longest ones requiring only about 20 percent more time than the shortest--thus giving partial support to a theory of perception in word wholes. However, even in this study, longer words did take longer to process.

Huey (1908) had subjects read down columns of single letters, 4, 8, 12, & 16 letter words. He found relatively little increase in the amount of time required to read words up to 8 letters long, but great increases in the time necessary for reading the longer words. He concluded that "recognition of familiar and comparatively short words is little affected by doubling the number of letters; and this seems confirmatory of the view that such words are recognized in one unitary act, as wholes (p. 101)."

Kinsbourne & Warrington (1962), after finding that 8 msecs. was the minimum exposure time necessary to process a single letter on a t scope, discovered that adding 2 or 3 more letters to process required no additional time, indicating parallel processing. However, only exposure time was controlled in this experiment. Response time was not measured. Extra

processing time may have occurred during the response interval which was not monitored. Therefore, their results may be an artifact.

Haber (1970) found that although naive subjects seemed to show serial processing in a word perception task, practiced subjects showed parallel processing when performing the same task.

Evidence for Serial Processing of Letters in a Word

In spite of other findings generally supporting parallel processing, Cattell (1889) found that when subjects were presented with unfamiliar words or longer words (over 8 letters) the words took longer to recognize than a single letter.

When Pillsbury (1897) had subjects read words briefly exposed in a tachistoscope, he noted that their ability to recognize typographical errors in the words decreased from first to last letter. Pillsbury concluded, "This seems to indicate that the subject read through the word from left to right (emphasis in original, p.350)," thus implying serial, letter-by-letter processing.

When Huey's (1908) subjects read columns of words and letters he found that even through the times required to recognize letters and short words (4 or 8 letters) were close, there was still a systematic increase in times for recognition according to word length.

Gough is perhaps the leading scientific proponent of serial processing. He stated (1971, p. 335), "I see no reason, then, to reject the assumption that we do read letter-by-letter. In fact, the weight of the evidence persuades me that we do so serially, from left to right."

Stewart, James and Gough (1969) had subjects read nouns 3 to 10 letters long as quickly as possible. Whereas many earlier studies had rather gross measurements of latencies involved in word recognition the Stewart et. al.

study measured the latency between stimulus onset and the pronunciation of the word as the dependent variable. They found that recognition times increased steadily with the number of letters per word. However, the function was negatively accelerated with a greater increase in latency with length for short words than for long words.

Gough & Stewart (1970) found that short words (3-letters) were recognized 35 msecs. faster than longer words (6-letters) when deciding whether strings of letters were words or not.

Pearson & Kamil (1974) presented nouns and verbs varying from 4 to 7 letters in length and measured subjects' response time to initiate pronunciation. Results showed a relationship between word length and recognition latency. However, this evidence in support of serial processing was found on only the first trial block. After repeated exposures, differences in latency as a function of word length disappeared.

From the conflicting evidence, it seems that in reading the level of processing can vary depending upon a number of factors. Such factors would include both subject variables (such as knowledge of the language, decoding skill, experience, etc.) and task variables (such as legibility of type, amount of context, word frequency, comprehension load, etc.).

Previous research (Terry, 1974) found that adults show evidence of both serial and parallel processing of words, but under different conditions. Adults seem to use serial processing when reading unfamiliar or distorted orthography and parallel processing when reading normal orthography. Since adults seem to show this flexibility in level of perceptual processing depending partly upon their familiarity with the orthography, it was hypothesized that beginning readers, being relatively unfamiliar with the orthography, would tend to show serial or letter-by-letter processing. In addition,

it was hypothesized that as reading skill increased, there would be an increasing trend toward processing units larger than single letters in parallel such as letter clusters or syllables.

As an index of the level of perceptual processing, the relationship between word length and response time in a word identification/categorization task was studied. If readers are able to identify long words just as quickly as short words, it is possible they are doing parallel processing. However, if each additional letter in length means a word requires more processing time, it is likely serial processing is occurring. The following experiment was done to further investigate specific instances of either serial or parallel processing in both normal and EMR beginning readers. The purposes of the experiment were to:

1) See if beginning readers show a significant relationship between word length and response time.
2) See if EMR and normal readers differ in their processing of information.
3) See if differences in accuracy and latency of word identification can account for differences in comprehension scores.

METHOD:

Subjects

Forty-six S's, 23 EMR and 23 N second grade children from the public school system of a large midwestern metropolitan area were studied. The average age of the normal children was 7.7 years (range 6.5-8.25 years) while the average age of the EMR children was 11.5 years (range 8.6-11.75 years).

Procedure

The experiment was conducted mid-way through the school year. Each child

was individually tested in a separate room. The children were shown individual words on a portable minicomputer containing a carousel projector (PL Systems Audio-Visual Trainer) and instructed to read the word out loud as soon as they could. The computer measured response time via a voice-operated relay system and automatically advanced to the next word.

The word lists consisted of forty 3-6 letter animal words, 10 of each word length. Words of each length were equated for word frequency, type of animal (e.g. mammals, birds, etc.) and number of syllables. Accuracy and latency data were gathered for each child.

The children were then given comprehension tests consisting of passages from first and second grade levels of the Gray oral reading and SRA silent reading tests.

On a second day of testing each child was given a categorization task presented via mini-computer. Words were categorized by pressing a button if the word was an animal, but not pressing if it was non-animal. Forty animal words plus 20 non-animal words 3 to 6 letters in length were used. The dependent variables consisted of latency and accuracy scores for normal and EMR children on an oral word identification task and on a silent word categorization task and oral and silent reading comprehension scores.

RESULTS:

A repeated measures multivariate analysis of variance showed a highly significant word length effect for both normal and EMR children for accuracy [$F(1,44) = 55.45$, $p < .00000001$] and latency [$F(1,44) = 66.92$, $p < .00000001$].

In comparing the two groups, the normal children were significantly more accurate in their word recognition than the EMR children, [$F(1,44) = 4.8$ $p < .03$], but there were no significant differences between the groups in

latency of response [$F(1,44) = 1.37$, $p < .24$]. A composite score combining both accuracy and latency data showed that the overall difference between the groups was not significant, $F(2,43) = 2.9$, $p < .06$.

Within each group of subjects there was no difference between oral response and button press response for either accuracy [$F(1,44) = 1.48$, $p < .23$] or latency data [$F(1,44) = 2.46$, $p < .12$].

An analysis of variance showed significant differences between the EMR and normal groups in both the first grade comprehension scores, [$F(1,44) = 6.5$, $p < .01$] and second grade comprehension scores [$F(1,44) = 7.01$, $p < .01$]. However, when initial differences between the groups in accuracy and latency scores were taken into account in an analysis of covariance, differences in comprehension between the groups were not significant for either first grade, [$F(1,42) = 2.49$, $p < .12$] or second grade [$F(1,42) = 2.38$, $p < .13$] comprehension scores.

DISCUSSION:

The hypothesis that beginning readers would show a significant relationship between word length and response time to read and/or categorize a word was confirmed. As Figure 1 shows, it took increasingly longer times for the children to recognize the longer words, implying serial processing. The discrepantly fast latency scores on 6-letter words of EMR children resulted because many of the children were not able to read the long 6-letter words at all (see Figure 2) leaving only the latency scores of the best and fastest readers to unduly influence the group mean.

The tendency for longer words to take longer to read was most extreme for the least accurate readers. As readers improved in accuracy, their latency scores to read words became more even over the varying word lengths,

approaching the flat line that would indicate parallel processing.

Both EMR and normal children showed similar kinds of processing. Both groups of beginning readers showed a significant relationship between word length and response latency implying serial processing. However, within both groups, some individuals, generally the most accurate, showed less difference between their latencies to recognize short and long words, indicating the possiblity of parallel processing.

The EMR group was significantly less accurate than the normal group and had significantly worse comprehension scores. However, when the groups were equated for initial differences in accuracy and latency, there were no differences between EMR and normal groups in comprehension. Thus, differences in accuracy and latency can explain differences in comprehension.

In summary, this investigation has shown that beginning readers do seem to show serial processing with shorter words being identified and categorized faster than longer words and with response times increasing with each additional letter. In addition, it was found that differences in the accuracy and latency of reading individual words can account for differences in comprehension.

This study dealt with the hierarchical level of perceptual processing used by beginning readers and did not include any pedagogical interventions. However, the results do have possible implications of interest to those involved in reading pedagogy. Beginning readers seem to show serial or letter-by-letter processing rather than processing larger units (e.g., syllables, morphemes, or whole words) in parallel as fluent readers do. Since qualitative differences in processing seem to exist between beginning and skilled readers, we ought to be wary of assuming that the way to teach beginning readers is to start them out with the same strategies used by fluent readers. A possible pedagogical alternative is to start at the beginner's current level

of competence in processing and help him or her master the sight and sound discriminations within the words to a state of automaticity. Once the word parts such as letters or letter clusters are mastered to a point where they can be recognized without extreme focal attention, attention can be focused on larger, more meaningful units resulting in increased comprehension.

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FIGURE1: Response Time to Orally Identify Words (Normal and EMR Subjects)

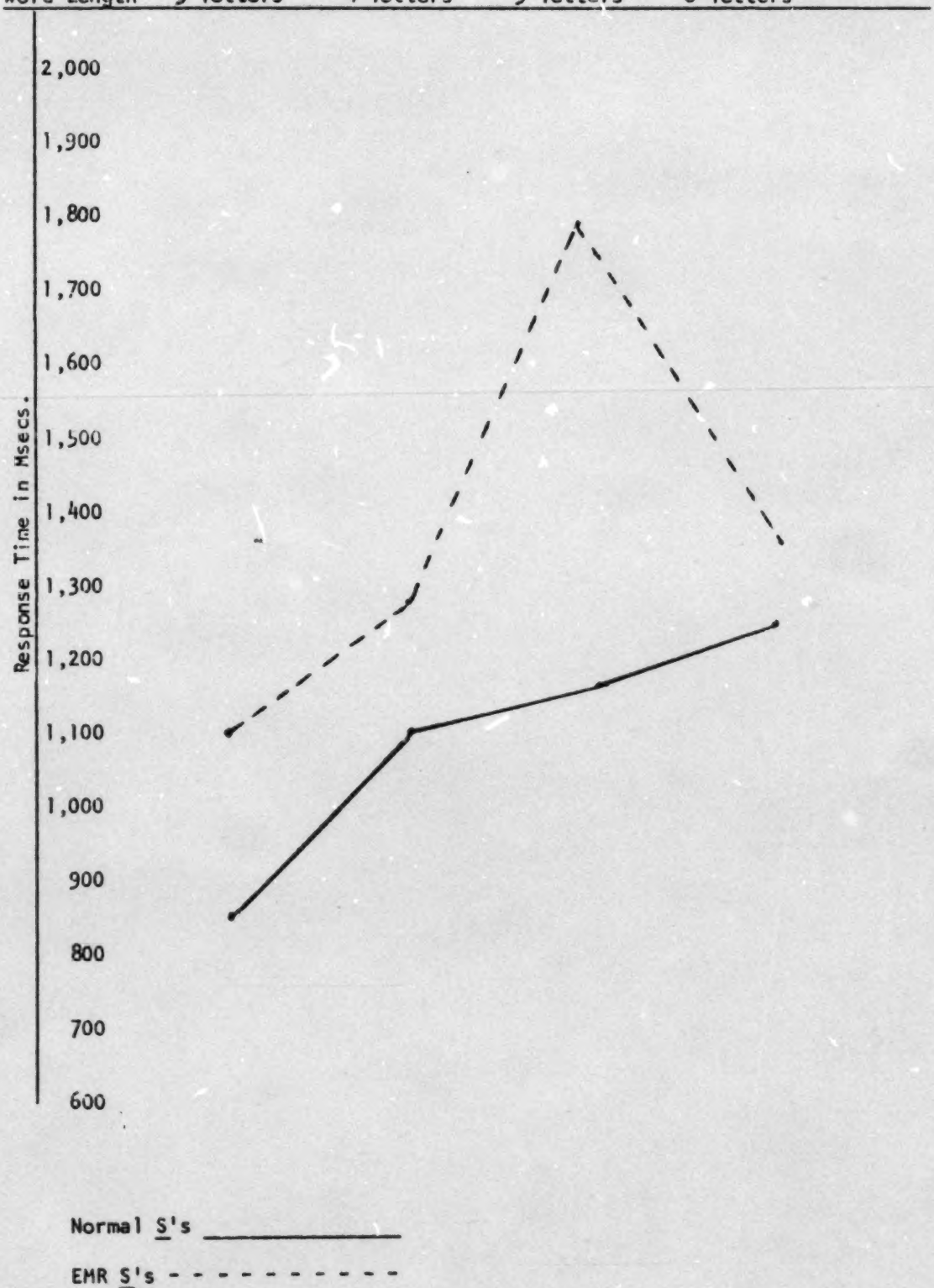

FIGURE 2: Accuracy in Orally Identifying Words (Normal and EMR Subjects)